Living with Uncertainty in Fisheries Management

or

"*Uncertainty is a Certainty*"

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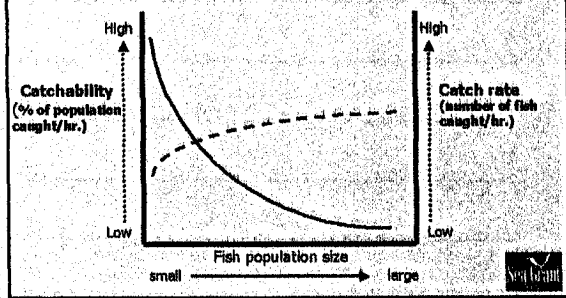
Has Fisheries Management *Failed* Us ??

- More failures than successes in both marine and freshwater fisheries.
- Many fisheries have "collapsed" from overexploitation.
- Little consideration of "risk" in communication and decision-making.
- Failure to utilize better precautionary management.
- Fishery collapses can be "invisible", hence are often only recognized **after** they have occurred.
- Conflicting values between user groups: recreational vs. commercial interests.
- Biological and ecological risks difficult to quantify vs. economic risks.
- Few fishery recovery plans exist.
- Management objectives are often poorly defined.
- Failure to take multi-species, ecosystem approaches to management.
- Scientific methods are sometimes flawed.
- Disconnect between scientists, assessment biologists, and the public.
- Science vs. assessment: Conflicting management needs.
- Lack of data integration.
- Political/economic decisions can often outweigh scientific data.

Hidden Effects of Depensatory Mortality in Fisheries

Definition: *Increasing* mortality of fish as their populations are *decreasing*



Typical Angler Beliefs

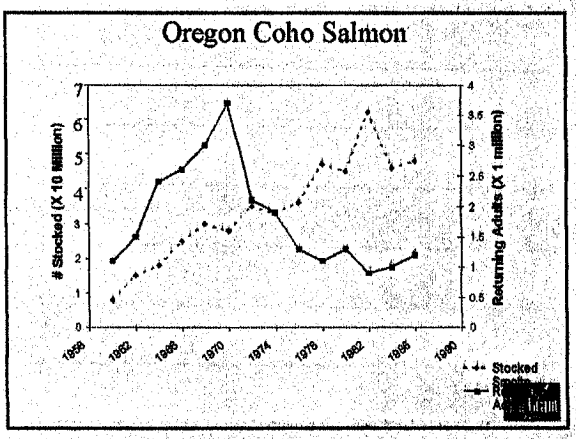
- Fisheries science, management and fisheries assessments are not objective, but reflect political agendas.
- Science is too conservative, places too much emphasis on unknown risks.
- Scientists make unrealistic assumptions about the biology and population dynamics of fish.
- Fisheries assessments employ the same techniques each year, sample the same areas, and don't keep up with latest technology.
- Fishing regulations change too often and too quickly, before management actions can be evaluated.

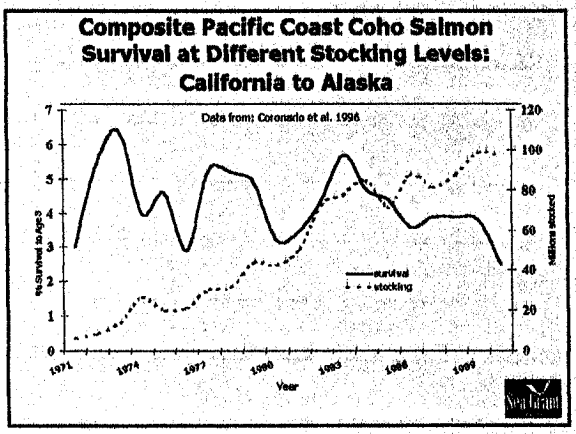
What is Uncertainty?

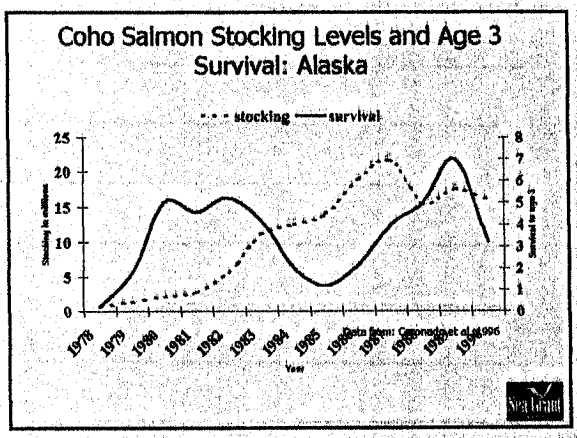
- Major resource management dilemma !!
- Wide range of possible outcomes, rare events and "surprises".
- Dynamics/instability of nature, political systems and institutions.
- Poor understanding of how nature really works.
- Large spatial and temporal scales of nature.
- Poor ability to predict future physical environments and biological responses.
- What management decisions to make ? ultimate effects?
- What are the risks? How can we manage/contain risks?
- Largely undefined resource management objectives.
- Lack of data integration.
- Conflicting interests among various user groups.
- Addressed largely by ***sophisticated*** modeling and intensive data collection/analysis.
- A *CONCEPT* to be better incorporated into Great Lakes management.

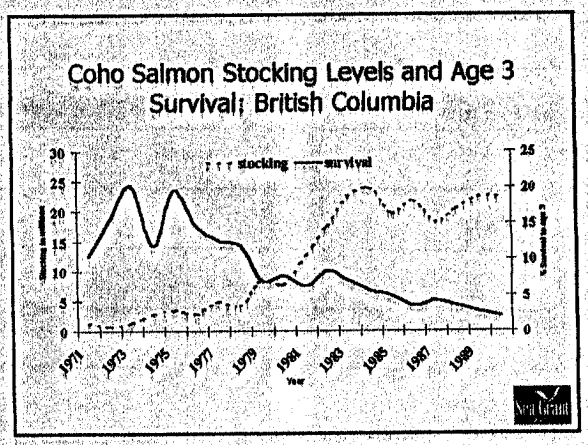
Fisheries Uncertainties in the Great Lakes

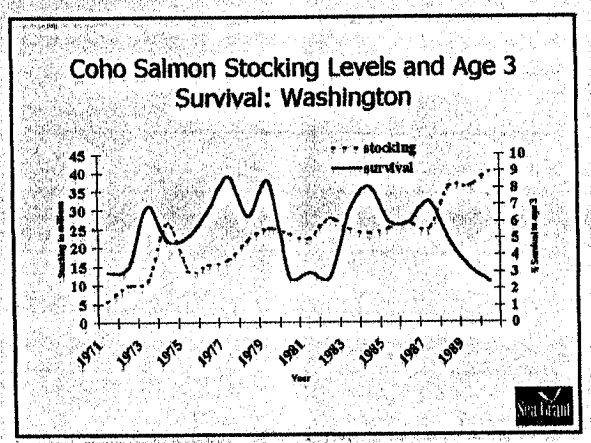
- How many fish are there in the lake?
- How many young do they produce each year? What factors influence numbers of offspring produced?
- How many fish survive? What are the sources of mortality? How much does each effect fish during their life span?
- How many fish should be stocked? Are there enough or too many stocked into the lake? What happens to them after stocking?
- Who eats who and how much?
- What are the best ways to sample fish to get good information?
- How many fish are really caught each year? How does angling effect these fish populations? Are there too many being caught?
- Where is the lake ecosystem going? What changes are going on? What will happen down the road? Can we prevent unforeseen problems?
- What are the impacts of invasive species? How many more are on their way? Can we prevent more from entering the lakes?
- **What are the best ways to manage the fisheries?**

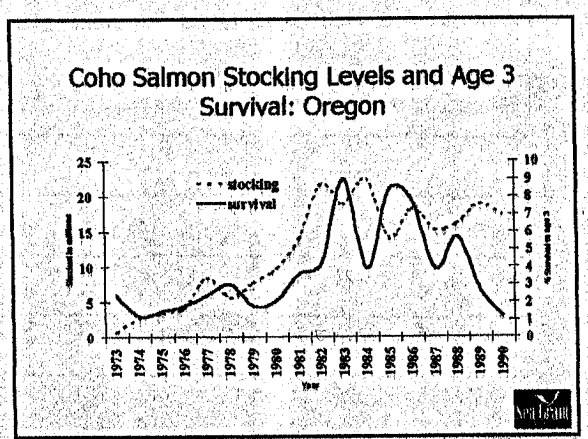

Oregon Coho Salmon
Stocked (X 10 million)
Returning Adults (X 1 million)
Stocked
Returning Adults

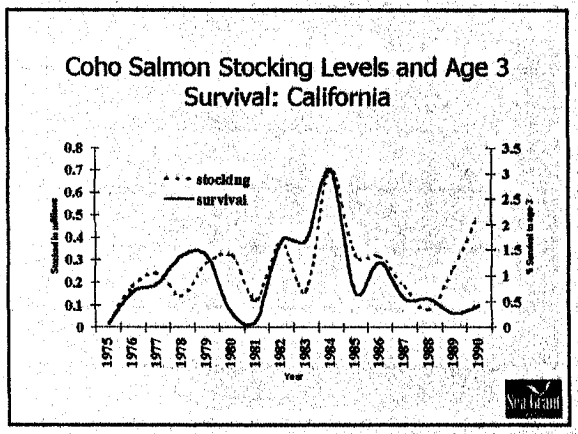

Composite Pacific Coast Coho Salmon Survival at Different Stocking Levels: California to Alaska
Data from: Coronado et al. 1998
% Survival to Age 3
Millions stocked
survival
stocking
Year

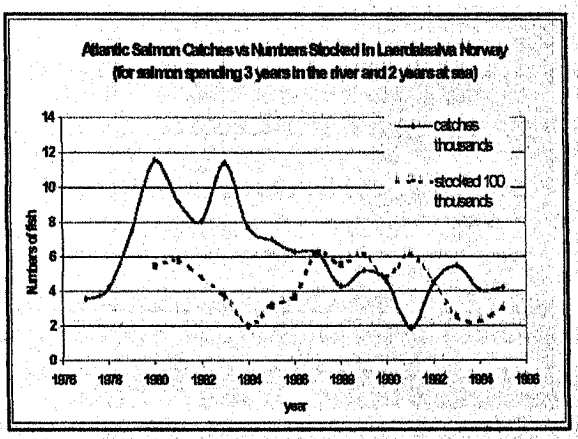

Coho Salmon Stocking Levels and Age 3 Survival: Alaska
stocking
survival
Data from: Coronado et al. 1998
Year

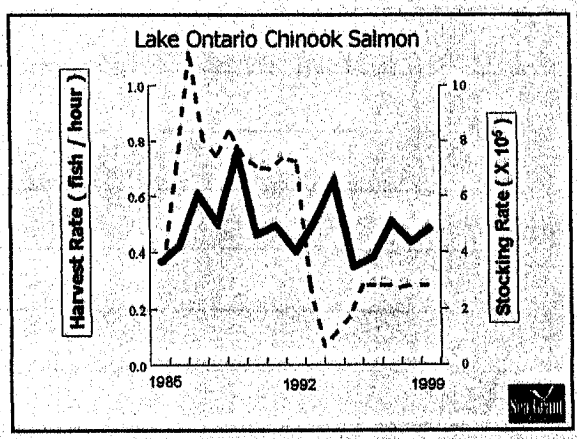

Coho Salmon Stocking Levels and Age 3 Survival; British Columbia
stocking
survival
Year
Sea Grant


Coho Salmon Stocking Levels and Age 3 Survival: Washington
stocking
survival
Year
Sea Grant


Coho Salmon Stocking Levels and Age 3 Survival: Oregon
stocking
survival
Year
Sea Grant


Coho Salmon Stocking Levels and Age 3 Survival: California
stocking
survival
Year


Atlantic Salmon Catches vs Numbers Stocked in Laerdalselva Norway
(for salmon spending 3 years in the river and 2 years at sea)
catches thousands
stocked 100 thousands
Numbers of fish
year


Lake Ontario Chinook Salmon
Harvest Rate (fish / hour)
Stocking Rate (X 10⁶)
1985
1992
1999

The 3 Types of Uncertainty Encountered in Fisheries Management:

1. **Random fluctuations.**
2. **Uncertain population parameter estimates and "states of nature."**
3. **Structural uncertainty.**

1. Random Fluctuations in Fisheries

- **Comparatively well-studied and understood.**
- **Oscillations around some mean value.**
- **Received less modeling attention than for parameter uncertainties or states of nature.**
- **Examples:**
  - **Climate: cyclic patterns, storms,wind direction/speed, temperature, upwellings.**
  - **Economic.**
  - **Political trends.**
  - **Institutional situations.**
- Three approaches
  - **Stochastic optimization -- derivation of optimal harvest rates**
  - **Simulation models -- examination of random dynamics, comparison of management actions, evaluation of mean performance and variability.**
  - **Behavioral modeling -- exploration of individual/aggregate fishing stakeholder economic responses to uncertainty. i.e. levels of risk aversion and preference**

2. Uncertainties of Parameter Estimates and States of Nature in Fisheries

- Parameter estimates:
  - **Survival/recruitment/catch/growth rates, year class strengths.**
- States of nature:
  - **fish population size, age structure.**
- Both related to random fluctuations.
- Improved with long-term data sets, increased understanding over time.
- Application of simulation & optimization techniques:
  - **Fitting functional population dynamics relationships.**
  - **Risk analysis to assess implications of alternate management strategies.**
  - **Bioeconomic modeling.**
  - **Accounting of management uncertainty and, proper utilization & seeking new information.**
- Statistical approaches to parameter estimation.
  - **Bayesian methods for decision making.**
  - **Fisherian methods for better data understanding.**
  - **Meta-analyses for parameter estimation.**

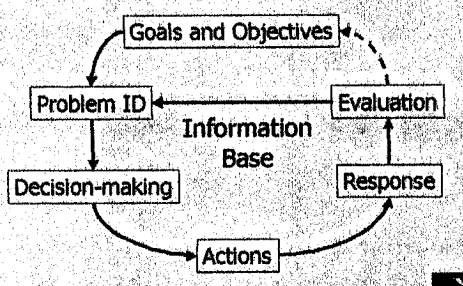
3. Structural Uncertainties in Fisheries

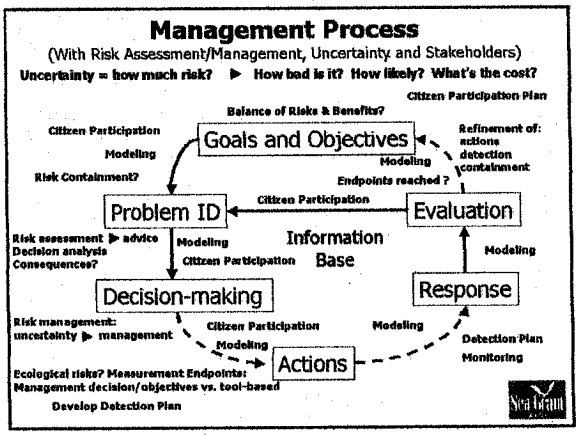
- Structural uncertainty is the greatest challenge, little studied.
- Major impact on fisheries management outcomes – many surprises, directly related to fisheries management policy.
- Reflects poor fundamental understanding of fisheries system nature.
- Less amenable to modeling approaches.
- Implications:
  - **1. Future research priority – development of improved analytical methods**
  - **2. Current efforts – changing management practices.**
- Examples:
  - **Spatial complexity related to fish distribution and movements.**
  - **Fish-fish interactions i.e. predation, stock-recruitment.**
  - **Fish-environment interactions i.e. climactic effects.**
  - **Technological changes.**
  - **Management objectives or goals that are driving decision-making.**
  - **Fishing stakeholder objectives or goals driving their decision-making.**
  - **Fishing stakeholder responses to specific regulations.**
  - **Institutional (agency) arrangements or how fishing stakeholders adapt to new management institutions.**

Three Ingredients for Sustainable Fisheries Management in the Face of Uncertainty

- **Robust management**
  - **Difficult to apply.**
  - **Choose management approaches less sensitive to uncertainty.**
  - **Fisheries outcome will not be disastrous even if beliefs about fisheries structure & dynamics are incorrect.**
  - **Some minimal level of success in attained societal objectives is achieved within a plausible range.**
- **Adaptive management**
  - **Stresses flexibility, new information integrated with existing on regular basis with regular reassessment of actions.**
  - **Continual learning about the system over time by monitoring.**
  - **Adapt to changes in a timely manner to "surprises".**
    - ✓ **Passive adaptive – updating parameter estimates as new information is available.**
    - ✓ **Active adaptive – deliberate efforts to accelerate learning process by experimental probing of fisheries.**
- **Precautionary management**
  - **Determination of the extent to "err on the side of caution".**
  - **Risk assessment.**
  - **Balancing risks – tradeoffs: where should the burden of proof lie?**

The Management Process




Management Process
(With Risk Assessment/Management, Uncertainty and Stakeholders)
Uncertainty = how much risk? ▶ How bad is it? How likely? What's the cost?
Citizen Participation Plan
Balance of Risks & Benefits?
Citizen Participation
Goals and Objectives
Refinement of: actions detection containment
Modeling
Modeling
Risk Containment?
Endpoints reached ?
Problem ID
Citizen Participation
Evaluation
Risk assessment ▶ advice
Decision analysis
Consequences?
Modeling
Citizen Participation
Information Base
Modeling
Decision-making
Response
Risk management: uncertainty ▶ management
Citizen Participation
Modeling
Modeling
Detection Plan
Monitoring
Actions
Ecological risks? Measurement Endpoints:
Management decision/objectives vs. tool-based
Develop Detection Plan
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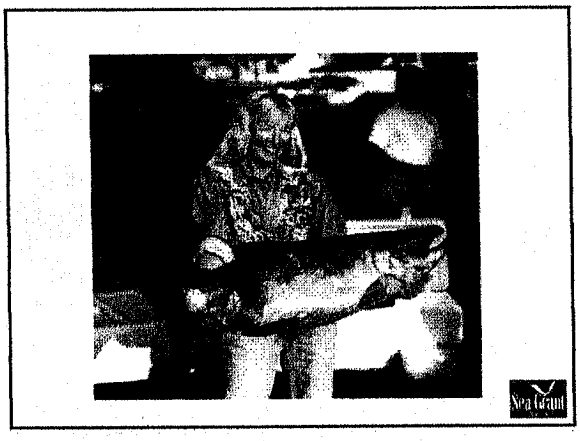
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